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Allusion was made in the last *Monthly Notices* to an expedition which Government contemplated despatching to the Island of Teneriffe. Professor Smyth, to whom the charge of the expedition was confided, has since proceeded to his destination. The readers of the *Monthly Notices* will be gratified to learn that he was furnished with the means of transport thither by Robert Stephenson, Esq. the eminent engineer, who munificently placed his private yacht Titania at the disposal of Professor Smyth.

The Royal Academy of Sciences of Göttingen has presented to the Society two impressions of a medal struck in honour of the illustrious Gauss, one in silver and the other in bronze. This interesting memorial is 2¼ inches in diameter. On the obverse is seen the head of Gauss, with the inscription:

CAROLVS FRIDERICVS GAVSS
NAT. MDCCLXXVII. APR. XXX. OB. MDCCCLV. FEB. XXIII.

Upon the reverse is a wreath of ivy, within which are to be read the words:

GEORGIVS V. REX HANNOVERAE,
MATHEMATICORVM PRINCIPI.

Around the wreath we read:

ACADEMIAE SVAE GEORGIAE AVGVSTAE DECORI AETERNO.

Suggestions respecting a Method for determining the Brightness of the Minor Planets. By Professor Argelander.*

The author commences this Paper with some preliminary remarks on the importance of observations of the brightness of the minor planets. It is plain that researches of this nature, if planned with intelligence and prosecuted with zeal for a considerable length of time, might lead to various important conclusions, not only with respect to those bodies themselves, but also relative to many other interesting questions of astronomy,—conclusions which are the more important the less reason we have to hope to arrive at them by any other means. The author, accordingly, proceeds to give a few hints relative to the most suitable mode of conducting observations of this kind. They are merely hints; but as they are founded upon long personal experience, they may not be without some use. Moreover, an expert observer will have no difficulty in applying to them various

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* *Ast. Nach.* No. 996.

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modifications, which may adapt them more effectually to the object he has especially in view.

The points which the author considers to be mainly worthy of attention in observations of this kind are the following:

1. Since we have reason to suppose that all the small planets revolving between *Mars* and *Jupiter* have had a common origin, and have passed through the same stages of physical organization, we may conclude that they are all characterised by the same, or at least *nearly* the same, natural colour of surface. Hence the determination of their relative brightness would serve to indicate their relative magnitudes; and consequently, we might arrive at a knowledge of their absolute magnitudes, if we should once be in a position to determine the apparent diameter of one of them. It is not improbable that, in the course of time, we may be enabled to accomplish this object. No reliance can be placed upon any results of this nature which have been hitherto obtained by observers; or, at all events, they can only be considered as affording, in each instance, a superior limit of the true measure. It cannot be doubted, however, that the immense telescopes, which are now directed towards the heavens in different parts of the world, will enable the observer, under favourable circumstances, to arrive at trustworthy results in relation to this object. Hence the determination of the *mean brightness*, and the comparison of the values of that element for the different planets, must form one of the principal objects of research.

2. It is well known that observers have suspected variations in the brightness of several of the minor planets, which seemed to indicate a rotation on an axis. The author himself had announced an observation of this kind, which appeared in No. 325 of the *Astronomische Nachrichten.* Such a conclusion, however, is very doubtful, the influence of atmospheric circumstances being very deceptive. The atmosphere, especially in our latitudes, is scarcely ever free from vapours. Even during apparently the most serene sky the heavens are here and there disturbed by very minute vapours, the presence of which is recognised by the fact that very faint stars suddenly vanish altogether, and soon reappear; while others in their vicinity, which were easily perceived, now cease to be visible. It is manifest that such disturbing causes must exercise an influence upon the brightness of stars which do not vanish altogether. In observations with illuminated fields of view, we have to encounter another difficulty arising from the circumstance of the illumination being not always the same. This must be adapted to the brightness of the object to be observed. The degree of faintness of the field affords now, indeed, an estimate of the brightness of the star, but a very imperfect one, since the eye very soon accustoms itself to a faint illumination, and imagines it to be more intense than it really is. It is only by direct and repeated comparisons of two stars that we can hope to arrive at anything approaching to trustworthy results. In this way, however, we may succeed in de-

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tecting real variations of light in the small planets. Should these arise from the existence of irregularities on the surfaces of the planets combined with a movement of rotation, they ought, as a necessary consequence, to return at regular intervals of time. It is possible, however, that they may be due to other causes. It seems, indeed, very probable, that the space between the planets of our system is not absolutely empty, but is pervaded more or less by a fluid substance, or by small bodies. If the orbit of *Mars* was encompassed by a system of aerolites similar to those which we perceive in the neighbourhood of the terrestrial orbit, or if such a system of aerolites revolved in the interval between *Mars* and the small planets, the light of the latter might undergo a sensible diminution, and we should thereby be enabled to detect the existence of the revolving bodies. Variations of light of this kind, as well as possible fluctuations in the atmospheres of the small planets, would be distinguished by an absence of periodicity from those which would be disclosed by a movement of rotation. In order to detect such variations, it would be necessary to institute comparisons at different times, partly in close succession, partly at wider intervals of time apart.

3. Our knowledge of the relative brightness of the stars in the different classes of magnitudes is still very imperfect. We know only very superficially how the different classes of magnitudes, according to which we are accustomed to arrange the stars, are related to the quantities of light which they transmit to the eye. The photometric determinations hitherto executed in reference to this object deviate so considerably from each other that they can only be regarded as rough approximations. This arises partly from the imperfect means which we possess for measuring light, especially when the question relates to faint stars, and partly from the difficulty of employing those means in the execution of large masses of observations, whereby the fluctuations in the condition of the atmosphere might be eliminated. To this we must add the different impression which differently coloured light produces upon the eye, the influence exercised by circumstances depending on the peculiar constitution of the observer's eye, and by the particular kind of telescope employed in the observations. Red light, for example, makes a considerably fainter impression upon the eye of a short-sighted than upon that of a long-sighted person; also in small telescopes the impression produced is fainter than in more powerful instruments. Now, the proposed method of observation must solve all these ambiguities. If we compare the small planets in every possible variety of distance from the sun and earth with a series of well-chosen fixed stars, and if we hence calculate according to photometric principles the quantities of light which we receive from the planets at the individual distances, we shall thereby become acquainted with the relations between the different magnitudes, at least up to the sixth magnitude (through *Vesta*), and thus a scale might be constructed which would serve as a guide to observers in the estimation of magnitudes. From such

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materials there might be deduced much more trustworthy conclusions than have been hitherto arrived at respecting the general distribution of the stars according to their different distances and the arrangement of the stars in the system constituting the milky way. By means of observations of this kind the question might also be decided whether the celestial regions beyond our solar system are pervaded by a substance of unequal density, since the occasional interposition of the more compressed parts of such a medium, arising from the movement of the solar system in space, would cause the stars to assume a fainter appearance. Olbers, and in more recent times Sir John Herschel, have shown that such an hypothesis is by no means improbable, and would afford an easy explanation of many facts which have been established with a greater or less degree of certainty.

4. Imperfect as is our knowledge of the absolute brightness of the stars, the information which we possess respecting their relative brightness at different altitudes above the horizon is equally unsatisfactory. The law according to which our atmosphere absorbs the light of the stars at different altitudes has repeatedly formed the object of research since the times of Bouguer and Lambert, but it appears that notwithstanding even the careful researches of Seidel the requisite degree of certainty has not been attained. This arises chiefly from the fluctuations of our atmosphere, the injurious effects of which can only be eliminated by means of a large mass of observations. This circumstance must therefore be taken into account in devising a proper method of observation.

In order, then, to attain these various ends in greatest perfection, and as free as possible from constant errors, the author suggests the following course of procedure :—

1. First, it will be necessary to select a series of fixed stars of different magnitudes, which may serve as points of reference for comparisons of brightness. Such stars can only be found in the region of the pole, where, in consequence of their almost uniform, and in our latitudes pretty considerable altitudes above the horizon, the brightness of the stars is not sensibly altered by the extinction of the rays of light in the course of their passage through the atmosphere. The region between δ *Ursæ Minoris* and 24 *Cephei* (Hev.) is well adapted for this purpose. The latter star, and consequently the entire region, is easily recognisable by means of four stars situate near it, and forming the figure of a rhomboid.[*] The region comprises stars of all degrees of brightness from the sixth to the tenth magnitude. Even fainter stars

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[*] The positions of these stars for 1855 and their approximate magnitudes in integers and decimals are the following :—

M	h m	° ′	M	h m	° ′
8·3	20 17	+88 33	9·3	20 30	+88 47
9·0	20 24	+88 26	8·5	20 55	+88 41

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will be found in abundance if the observer should desire to include such in his comparisons.

2. A number of these stars, including every shade of brightness, must now be carefully compared together, and their relative brightness determined by means of repeated observations. The author alludes to the method which has been employed for effecting this object by comparisons of equal brightness. He remarks that, according to his own experience, one may judge with equal precision respecting minute gradations of light, and that results equally worthy of confidence will be obtained if the observer should compare the star whose brightness is to be determined with two other stars, one of which is a little brighter, and the other a little fainter. He accordingly proposes the method which he employs in the observation of variable stars, and which has been found by several other observers to be a convenient one. Designating the faintest of the stars by 0, the next brighter by 1, 2, 3, &c., a scale of comparison will thereby be formed which will serve to ascertain the relative brightness of the small planets. By observing the planets at various distances from the sun and earth, materials will be obtained for comparing the luminous intensities of the stars of the scale with their estimated magnitudes.

3. It would not be advisable to compare the planet directly with the stars of the scale which approach it in brightness. Our knowledge of the light-absorbing power of the atmosphere at different altitudes is not only too uncertain, but the absorption varies too much with the time and the azimuth of the object to admit of this process. The observer, therefore, on every occasion, when he wishes to determine the brightness of a planet, selects two stars in its vicinity, one being a little brighter, and the other a little fainter than it. It is not necessary that these stars should be visible in the field of the telescope at the same time with the planet. It is even desirable to select them at some distance from the planet, preceding or following the latter, according as its motion is retrograde or direct, so as to be enabled to employ the same stars of comparison for several days. By this means the observer is enabled to recognise with greater facility the existence of slight periodic variations in the brightness of the planet, but the principal advantage which he derives from the process consists in the elimination of the effects of any irregularities in the condition of the atmosphere in the region of that planet and that of the scale. The stars which have been directly compared with the planet must now be compared with as many stars of the scale as possible, and it will be desirable to institute this latter comparison on the same nights that the comparisons of the planet have been made. It is only necessary to select such stars as form easily recognisable configurations, so that they may be found again without any difficulty. For this purpose it will be desirable that the observer should trace out upon a chart the course of the planet to be observed, and that he should make himself well acquainted

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beforehand with the stars near which it passes. If, after the lapse of some time, the planet has removed too far from the first stars of comparison, or if its brightness has varied too considerably, the observer should then select new stars according to the same principles, comparing these not only with the stars of the scale, but also, if practicable, with the former stars of comparison, always endeavouring by a multiplication of comparisons to render the results more trustworthy. Should the planet after quitting a stationary point revisit the same region which it had previously traversed, the observer must then search for stars approaching it in brightness, and compare these, if necessary, by means of other stars of intermediate brightness, with the former stars of comparison. Moreover, should several small planets happen to be all at once in the same region of the heavens—a circumstance which frequently occurs,—and should they not differ too much in brightness, the observer ought not to omit carefully comparing them together as often as occasion offers.

4. In applying this method of observation the process of comparing with the scale will be found to be very difficult, indeed the certainty of the result will be very much endangered, if the observer should have at his disposal only one telescope, which he turns alternately upon the scale and the region of the planet. Even if he should have an assistant to attend to the adjusting of the instrument, and if the latter should be furnished with circles for this purpose, still it will be impossible to prevent extraneous light from entering the eye of the observer. In every case the time which elapses between the two corresponding observations will be too long for the impression which the brightness of the first star has left in the eye to remain undiminished until the observer is enabled to consider the second star. In order to obtain a result which shall be in any degree worthy of confidence, a great many comparisons must be instituted, and each observation must occupy a considerable interval of time. The observer must abandon the use of very large telescopes in researches of this kind, and must content himself with instrument of moderate power. Telescopes from the Munich workshops of 48, and even 42 lines aperture, will amply suffice for accurate comparisons of stars to the tenth magnitude. They possess at the same time the advantage of being applicable to observations of the brightest of the small planets in all stages of brightness, which is not the case with respect to large refractors. In these the stars of the sixth and seventh magnitudes, and even the brighter stars of the eighth magnitude, have so much light that it is impossible to estimate their brightness with any degree of certainty.

The observer must now direct one of the telescopes to the scale, and the other to the region of the planet. The two instruments must be placed so that the eye-pieces shall be near to each other, and the eye in a few seconds can pass from the one to the other. It is a matter of importance that both telescopes should have the

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same optical power; but as this object cannot be rigorously accomplished, it will be desirable that the observer should direct each telescope alternately to the scale. When once the relative optical powers of the two telescopes have been thus ascertained, the observations may be henceforward prosecuted without having recourse to an interchange of instruments.

5. It is important that the observations should be prosecuted in the dark, and that no extraneous light should enter the eye until the observation is quite finished. The observer must, therefore, arrange beforehand, so as to be enabled to write in the dark without confusion. A framework or system of strips of black paste-board, laid upon paper, will here perform good service, since the strips of paste-board, which may be seen even in the darkest nights, will serve as lines for separating the individual observations from each other.

6. No observations should be made during the prevalence of a fog, even although it should appear to be uniformly distributed over the whole heavens. Nor should any be made during bright moonlight, especially if the moon should happen to be anywise near the planet which is being observed, since in that case the illumination of the ground of the heavens would be too unequal in the region of the planet and that of the scale. Still less should observations be made at altitudes lower than 10°. Near the horizon the vapours arising from the surface of the earth, as well as the radiation of heat from the latter, exercise too great or too fluctuating an influence, and render the extinction of light too uncertain, both absolutely and in different azimuths, to hold out any prospect of deducing trustworthy results from such observations, even although repeated many times. Even the observations comprised between 10° and 20° of altitude will for the most part serve merely for ascertaining the extinction of light, and only in exceptional cases and under especially favourable circumstances can they be employed for the ultimate object of the investigation.

7. It will be desirable to observe only such planets as, at the time of observation, have attained an altitude equal to that of the scale, in order not to be too dependent on the law of the extinction of light which has been found. In doubtful nights, observations should be made only of such planets as have attained or exceeded that height. In very bright nights, however, and especially when the weather holds out the prospect of a continuance of clear nights, observations should be made repeatedly, and at as different altitudes as possible. The observations of the same star should not succeed each other too quickly. After the lapse of an hour, or an hour and a half, the observer will have already almost entirely forgotten the numbers of the earlier observation, and he may, therefore, institute a second observation, without having his mind occupied with the one preceding.

These are the methods and precautionary measures which the author suggests for the purpose of giving due efficacy to such ob-

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servations. Their adaptation to the object of research will be easily seen; but the attentive observer will undoubtedly modify them to a considerable extent. They will attain the end which the author had in view, if they spare the observer a series of fruitless attempts.

The Minor Planets.

In conformity with the plan adopted at the Observatories of Washington and Altona, Professor Challis announces his intention of confining in future his observations of the minor planets with the Northumberland equatoreal to the following eight bodies: *Flora*, *Metis*, *Victoria*, *Themis*, *Proserpina*, *Bellona*, *Urania*, *Leucothea*.

Professor Challis purposes to observe the others occasionally, but to give these his particular and continued attention.

Dr. Gould, editor of the *Astronomical Journal* (U.S.), states (No. 94, p. 176,) that Professor Brünnow has undertaken, in behalf of Ann Arbor Observatory, of which he is director, the regular observation of the following eight asteroids:—

Flora, Victoria, Astrea, Metis, Proserpina, Calliope,
Euphrosyne, Hebe.

In order to facilitate and hasten this division of labour, Dr. Gould guarantees that four others shall also be regularly observed in the United States after the beginning of the year 1857; and he selects the following four as least likely to interfere with the preference of others:—

Vesta, Iris, Eunomia, Amphitrite.

Dr. Gould remarks that these will complete for the western continent its contingent of one half of the known members of the group. He could not, of course, have then been aware of the recent discovery of two new planets, nor of the proposal of Professor Challis.

ERRATA.

Page 173, *Lætitia*, April 19, App. N.P.D., *for* 78° 49′ 47″·13, *read* 77° 49′ 45″·31.
— 185, line 13 from top, *for* zinc, *read* time.